International Journal of Advanced Biotechnology and Research (IJBR)
ISSN 0976-2612, Online ISSN 2278–599X,
Vol-7, Issue-3, 2016, pp925-935
http://www.bipublication.com

Research Article

Corpuscle-Wave Duality of Discrete Systems at Nano-Scale Level

Kharkhardin Anatolii Nikolaevich, Kozhukhova Natalia Ivanovna,
and Strokova Valeria Valerievna
Department of Material Science and Material Technology,
Belgorod State Technological University named after V.G. Shoukhov, Russia

[Received-11/08/2016, Accepted-21/08/2016, Published-25/08/2016]

ABSTRACT
In the paper the results of study of wave properties for discrete systems with using of mathematical apparatus of discrete topology and application of its basic regularities for disperse materials, micro- and nanoparticles, topological and phase transportations as well as resulting effects and prognosis.

Keywords: discrete topology, disperse materials, critical states, clusters, nanoparticles, topological transformations

INTRODUCTION
Discrete systems are presented by materials, radiations and substances of real world, comprising of discreteness elements at different scale level with packing density of $\eta_1 \le 1$. Unity of continuous and discrete radiation and substances in the surroundings as well as its liquid and solid state leads to necessity to consider studied subjects in conjunction with geometry and physics i.e. discrete topology [1–4]. Discrete topology is science about ordered (crystalline) and disordered structures as well as physical state of objects in the material world which are discrete (naturally or artificially) at different scale level of corpuscle formations from atoms to astronomical body. Mathematical apparatus of its study is the obtained basic and new topological principles of discrete systems, demonstrating wave-corpuscle duality [5, 6]:

– recurrence equation of topological (phase) transportations (PTT):

$$\eta = \eta_1[1 - \frac{1}{3k\ln[2000(\sqrt{3}-1)^9\eta_1^5]}] = \eta_1[1 - \frac{1}{3k\ln(120.753857\eta_1^5)}], \qquad (1)$$

η_1 – packing density of discreteness element of radiation or substance;

– from the equation (1) the Gruneisen parameter for a lot of metals is following:

$$\Delta\eta = \eta_1 - \eta = \eta_1 / 3k\ln[2000(\sqrt{3}-1)^9\eta_1^5], \quad k \ge 1.$$

The obtained recurrence equation (1) allows plotting the scheme of PTT levels, physical states, determined by packing density of particles of disperse materials or atoms of crystalline materials (metals): solid state in triple point, solid state near to melt temperature, liquid and critical state [7]. Levels of topological (phase) state (PTS) of substance in form of tetrahedral join each other though points of overheated and super cooled states. They consist of three sublevels: homogeneous compact state; heterogeneous compact state with critical packing density and friable state (Fig. 1).

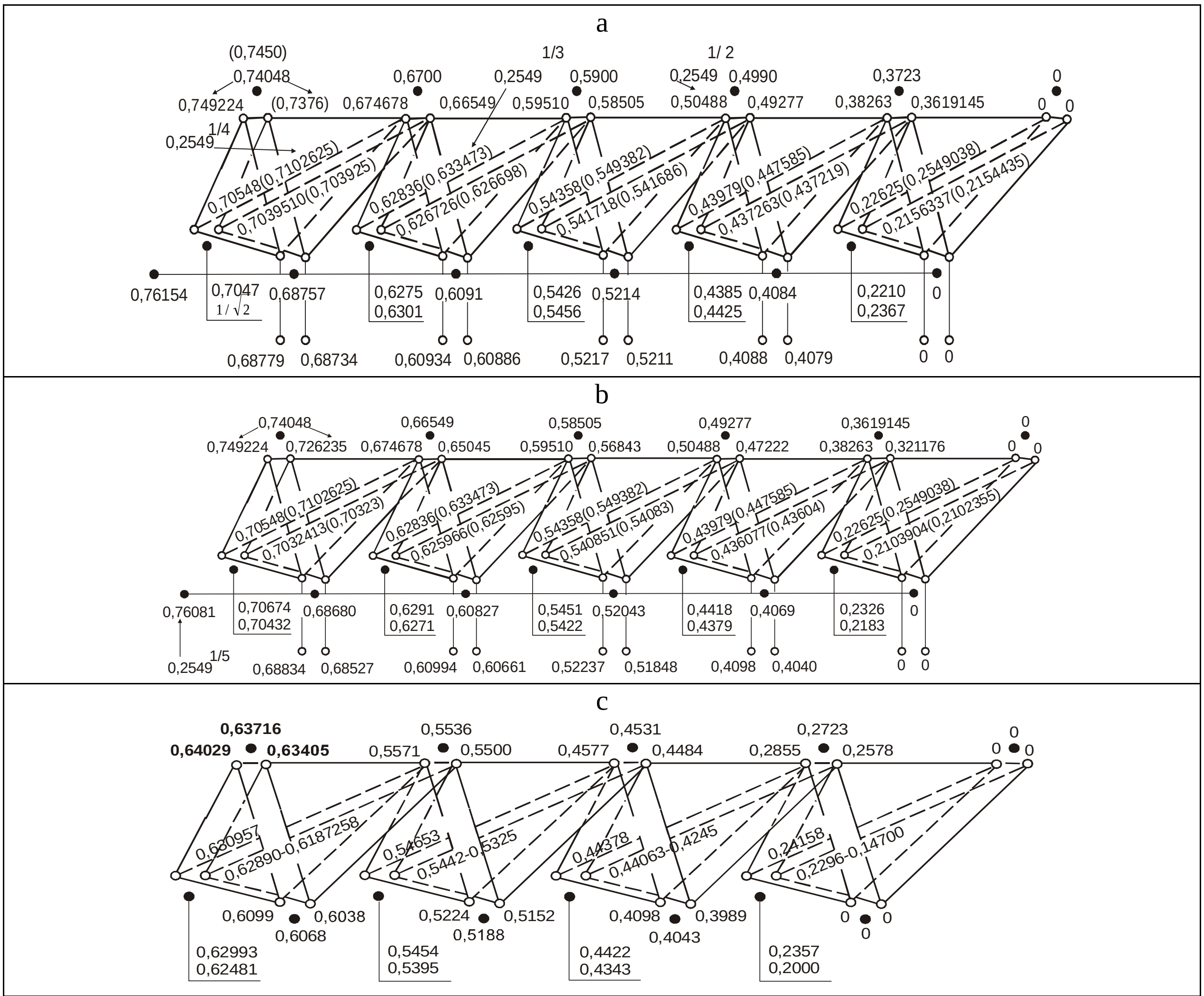


Fig.1. Schemes of PTT levels for substances: a) with hexagonal closely-packed lattice; b) with side-centered cubic lattice; c) with random structure

– changing of informational entropy when PTT processes [8], at $\eta_1 = 0.64029\ldots0.64976$:

$$\Delta S = k_Б \ln\left[\frac{\eta_1}{3k\ln[2000(\sqrt{3}-1)^9\eta_1^5]}\right] = k_В \ln\{\frac{0,6403...0,64976}{3\ln\left[120,754\left(06403...0,64976\right)^5\right]}\} \approx -2,5k_Б,$$

where k_B – the Boltzmann constant.

– polydispersed distribution of discreteness elements taking into account high-density random packing:

$$d_n / D = \left[1/10\eta_1(\sqrt{3}-1)^p\right]^n, \qquad (2)$$

D, η_1 – average size of narrow fraction of the largest discreteness elements and their packing density, respectively;

– index of density deviation of discreteness elements of radiation and substance:

$$C_3 = \eta_{c2} / k_1^n, \text{ when } n = 0,\ C_3 = \eta_{c2} \le \eta_1^n \approx 0.1.$$

n = (15…23)/3 depending of packing density of discreteness elements: for oriented atom packing in crystals at $0.6802 \le \eta_1 \le 0.7405$ $(18 \le n \le 23)/3$; and for random atoms packing – at $0.63096 \le \eta_1 \le 0.64976$ $(15 \le n \le 16)/3$.

$$C_3 = \eta_1^{23/3} = 0.74048^{23/3} = \eta_{c2} = 0.1 \text{ и } C_3 = 0.2549 \cdot \eta_1^m,$$

where m= 2 – for random atoms packing and m=(7…9.3)/3 – for oriented atoms packing.

$$C_3 \le \left(0.64658736...0.63347284...0.63095734\right)^5 \le 0.113015\ldots0.102009\ldots0.1.$$

$$C_3 = \eta_1^3\eta_1^2 = 0.6334728^3 \cdot 0.6465874^2 = 0.2542 \cdot 0.418075 = 0.1062768.$$

$$C_3 = \eta_{c1}\eta_1^2 = 0.2549 \cdot 0.64976^2 = 0.6402894^5 = 0.10761718778.$$

$$C_3 = \eta_{c1}\eta_1^2 = 0.2549 \cdot 0.6465874^2 = 0.10657.$$

$$C_3 = \eta_{c1}\eta_1^2 = 0.6465874^{10/3} \cdot 0.6465874^2 = 0.0977.$$

$$C_3 = \eta_{c1}\eta_1 = 0.74048^5 \cdot 0.74048 = 0.22262 \cdot 0.74048 = 0.100.$$

$$C_3 = \eta_{c1}\eta_1^{3,1} = 0.2549 \cdot 0.74048^{3,1} = 0.100.$$

– percolation level of electrical and physical processes [2]:

$$f_y = \eta_{c1}\eta_1 \le \eta_1^4 = 0.2549 \cdot 0.64976 = 0.1656..$$

$$f_y = \eta_{c1}\eta_1 \le \eta_1^4 = 0.2549 \cdot 0.640289 = 0.1632.$$

$$f_y = \eta_{c1}\eta_1 = \eta_1^4 = 0.2549 \cdot 0.6340528 = 0.6340528^4 = 0.1616.$$

$$f_y \le \eta_1^4 \le (0.6340528...0.6402894)^4 = 0.161622...0.168076.$$

$$f_y = \eta_{c1}\eta_1 = \eta_1^5\eta_1 = 0,74048^5 \cdot 0,74048 = 0,16485.$$

On the base of the equation (2) at n = 1, p = 6, p = 3 and p = 0 the following results:

– theoretical (canonical) density of random packing of spherical particles in case of absence of frictional forces and their interaction; the first critical (canonical) packing density of impacting particles when aggregation during the dry mechanical grinding as well as the second critical packing density when aggregation during the wet mechanical grinding, respectively:

$$\eta_{1т} \le 1/10(\sqrt{3}-1)^{6;3;0} \le 0.64976; \quad \eta_{c1} \le 0.2549; \quad \eta_{c2} \le 0.1.$$

– minimal linear dimension in volume of substance (if the wall (surface) affect absent) is following [1]:

$$D \ge \left[10\eta\left(\sqrt{3}-1\right)^3\right]^3 d \ge 60.38\eta^3 d\left(F_V / F_{elements}\right), \qquad (3)$$

η, d – packing density of discreteness elements and their average size, respectively; $F_V, F_{elements}$ – form-factors of the substance volume and discreteness elements, $F \ge 1$.

– the maximal density of random packing of spherical discreteness elements in spherical container:

$$\eta_1 = \left(\eta_{c1}\eta_{1т}^2\right)^{0,2} = \left(0.2549 \cdot 0.64976^2\right)^{0,2} = 0.1076172^{0,2} = 0.6402894.$$

– theoretical density of random packing of discreteness elements in compact (granular) volume or discreteness elements of substance and irradiation, respectively:

$$\eta_1 = \left(\eta_{c1}\right)^{1/3} = \left[1/10\left(\sqrt{3}-1\right)^3\right]^{1/3} = 0.25490381^{1/3} = 0.634052826,$$

$$\eta_1 = 1/10\left(\sqrt{3}-1\right)^3 = 0.254903810567665797 \xrightarrow{(1)}$$

$$\rightarrow 0.447584998986761523 \rightarrow 0.54938193018442289 \rightarrow 0.63347284052415.$$

– the parameter η_1 = 0.63347284 determines an occupied volume of a gram-mol of helium atoms in the following form:

$$V_c = C/0.63347284^{10/3} = 4.5804344 \text{ cm}^3,$$

where C – dimension constant, C=1 cm^3

At V_c= 4.5804 cm^3 the atomic radius of helium r = 1.2199558Å =0.122 nm. Experimental value of r is 0.122 nm.

– packing density of helium atoms in critical state is following:

$$\eta_{critical} = 0.2549 \times 0.64976^2 \times (\pi / 3\sqrt{2}) = 0.6402894^5 \times 0.74048 = 0.0796884;$$

As V_c = 4.5804 cm^3/mol, the critical helium volume is V_{critical} = 4.58043 cm^3/mol / 0.07969 = 54.479 cm^3/mol.

Experimental value of V_{critical} parameter is 54.474 cm^3/mol.

– density of random packing of discreteness element at friable disperse state:

$$\eta_1 \le 10\left(\sqrt{3}-1\right)^9 \le 0.6037693.$$

– critical densities of random packing of discreteness elements in disperse and fine disperse state:

$$\eta_{c1} \le 10\left(\sqrt{3}-1\right)^{12} \le 0.23686,\ \eta_{c2} \le 10\left(\sqrt{3}-1\right)^{15} \le 0.0929 \text{ etc.}$$

– size of corpuscular formations of substance according to equation (2) for different element pickings of discreteness elements at $n' = 3$, a $\eta_{c1} = \eta_1^3 = 0.2549038$ are followings:

$$D = \left(10\eta_1 / 10\eta_{c1}\right)^{mn/3} d / \eta_s^{1/9} = \left(\eta_1 / \eta_1^{n'}\right)^n d / \eta_s = \left(3.923\eta_1\right)^n d / \eta_1^{1/9}, \qquad (4)$$

$\eta_s = \eta_1^{1/9 \ldots 1/3}$ is packing density for atoms at surface of cross section of crystal cluster formations in terms of its random packing.

for close packing	$\eta_1 \le 0.74048,\ D \le 2.905^n d / \eta_s \le 3^n d,$
	$\eta_1 \le 0.68834,$
for icosahedral packing	$D \le 2.70^n d / \eta_s \le 2.70^n d / 0.9069^{3/4} \le 2.905^n d$
	$\eta_1 \le 0.64976,\quad D \le 2.549^n d / \eta_1^{1/3},$
for random packing	$\eta_1 \le 0.64029,\quad D \le 2.512^n d / \eta_1^{1/3},$
for free packing	

where $$\eta_s = \left(\pi/2\sqrt{3}\right)^{1/3} = 0.9069^{1/3} = 0.968 \approx \eta_1^{1/9} = 0.74048^{1/9} = 0.9672.$$

According to equation (4) at $\eta_1 = 0.68834$, n = 1 и $\eta_s = \eta_1^{3/4}$ = 0.9293, the icosahedral atomic aggregation (cluster) consists of one surface atomic layer. In case of absence of central atom the dimension of central pore is 0.9d that agrees with dimension of central pore in icosahedral packing of atoms contacting each others. The vacancies in crystals as well as potential opportunity of spherical aggregations growth are formed in such a manner.

– dimension of cluster formations and nanoparticles, where its unique properties are appeared [3]. The equation (3) can be presented in following form:

$$D = \left(3.923\eta_1\right)^{3n} d / \eta_1^{1/9} = \left(60.38\eta_1^3\right)^n d / \eta_1^{1/9} = \left(60.38\eta_{c1}\right)^n d / \eta_1^{1/9} = \left(60.38\eta_1^{n'}\right)^n d / \eta_1^{1/9}, \qquad (5)$$

$$D = \left(60.38\eta_{c2}\right)^n d / \eta_1^{1/9} = \left(60.38\eta_1^{n''}\right)^n d / \eta_1^{1/9}, \qquad (6)$$

$$D = \left(\eta_1 / \eta_{c2}\right)^{3n} d = \left(\eta_1 / 0.1\right)^{3n} d = \left(1000\eta_1\right)^n d. \qquad (7)$$

where the parameter n' =(11.5…12…12.4…15/3) determines a first critical density of regular atomic packing and n'' = (18…18.4…19…23)/3 is a second critical density of regular atomic packing at

$\eta_1 = 0.6802…0.6883 …0.6981…0.7405$, respectively; for random packing of discreteness element of substance such as micro- and nanoparticles of disperse materials – $\eta_{c1} = \eta_1^{(9...10...10,5)/3}$, and $\eta_{c2} = \eta_1^{(13,5...15...16)/3}$ at η_1 = 0.6038... 0.64029…0.64976, respectively.

– coordination number of discreteness elements: for random and regular packing the simplest equations are as follows, respectively:

$$Z = 8.5\eta_1 / 0.6340528 = 13.40\eta_1 \tag{8}$$

$$Z = 8.8\eta_1 / 0.6402894 = 13.74\eta_1 \tag{9}$$

$$Z = 12\eta_1 / 0.74048 = 16.20\eta_1. \tag{10}$$

J. Bernal in 1959 obtained the same result for similar plasticize balls, chalked and compressed into a one ball $(\eta_1 = 1)$. The figures obtained from the pressed balls have 13.3 grains, averagely, i.e. 13.3 contact points of central ball with neighbor ones in case of random packing [6].

– pair interaction potential of micro particles in critical state of dispersed material, obtained by dry and wet grinding:

$$\varphi = 4\varepsilon\left[\left(\frac{\sigma}{r}\right)^4 - \left(\frac{\sigma}{r}\right)^2\right], \tag{11}$$

or
$$\varphi = 4\varepsilon\left(\eta^{4/3} - \eta^{2/3}\right) = 4\varepsilon\eta^{2/3}\left(\eta^{2/3} - 1\right), \tag{12}$$

where *σ* is average diameter of monodisperse particles; *r* is average distance between interacted particles is determined from density of unconsolidated disperse layer.

Solution of the equations (11, 12) and the equation resulted from them ones for antiparticle forces as first-order derivative *do/do*=0 provides the values of the first and second critical density of random packing $\eta_{c1} \leq 0.64029^{10/3}$ and $\eta_{c2} \leq 0.64029^5$ respectively.

The equation (4) for emission and substance has low correlation with η_1:

$$D / \eta_1^n d = 60.38^n = 1;\ 60.38;\ 3645.37;\ 220096.456;\ 13288748.... \tag{13}$$

clusters and nanoparticles (*n* = 0…5) and minimal linear dimension of apparatus with disperse (granular) material in case of absence of wall effect (*n* = 3) [5].

Third constant of the equation (13) is included in equation for Plank's constant determination. The equation (4) with increasing of coefficient (*n* = 3) at higher level of substance discreteness can be presented in following form:

$$(D/d) = \left(60.37693\eta_i\right)^n = 1;\ 60.377\,\eta_i;\ 3645\,\eta_i^2;\ \mathbf{220096}\,\eta_i^3 \ldots$$

This equation at *n* = 3 can be transformed to following form:

$$(D/d)kC \leq \left(60.3769286\eta_i\right)^3 kC = 220096.456\eta_1\eta_2\eta_3 kC.$$

Left part of this equation is defined as **h/ē.** Using the obtained values of η_i for radiation and substance we have following:

$$h/\bar{e} = 220096 \cdot (0.54938193 \cdot 0.447584999 \cdot 0.25490381)\, k\,\mathrm{C}, \tag{14}$$

C – Dimension coefficient, C = $1 \cdot 10^{-21}$ erg·s/ea. CGSE;

When *k* = 0.9999671818563986 (value, obtained by ascendancy in equation (3) at η_1 = 0.64028942310500804 to 1 we have *h*/ē = $1.3795557985048946153708 \cdot 10^4 \cdot 0.9999671818564 \cdot 10^{-2}$ erg·s/ea. CGSE =$\mathbf{1.3795105240445931377 \cdot 10^{-17}}$ erg·s/ea. CGSE.

According to update data [4]: *h*/ē = $6.62606896 \cdot 10^{-27}$ erg·s/ea ($1.602176487 \cdot 10^{-19}$ Coulomb · 0,1c · $2.99792458 \cdot 10^{10}$ см/с) =$1.379510132183684 \cdot 10^{-17}$ erg·s/ea. CGSE, where ē = 1.602176487·10^{-29} C·0.1 s·2.99792458·10^{10} cm/s = 4.80320427187535·10^{-10} ea. CGSE; 2.99792458·10^{10} cm/s is value of light speed.

Second constant in the equation (13) is wavelength of Balmer series limit for visible range of dark-line spectrum for monoatomic gases:

$$\lambda_B = \frac{1\text{Å}}{(0.1\times 0.64976)^3 k^2} = \frac{100\,\text{Å}}{0.2549\times 0.64028942^5 k^2} = 3645.6(3645.6)\text{Å};$$

$$\lambda_B = \left[10\left(\sqrt{3}-1\right)^3\right]^6 / k^2 = 60.3769286^2\,\text{Å}/k^2 =$$

$$= 3645.37\,\text{Å}/0.9999671818^2 = 3645.6\,\text{Å}.$$

$$R_\infty = \left(0.640326743^5 \times 4 k_0'^{2/3}\right)/\left(\sqrt{3}-1\right)^3 \times 10^{-5}\,\text{cm} = = 1.09677585(1.096775)\times 10^7\,\text{m}^{-1}$$

Herewith $\lambda_B = 4/R_\infty$ = 4/1.09677585 · 10^7 m^{-1} = 3645.0533 Å .

To calculate the quantum-mechanical parameter the equation for λ_B is shown in following form:

$$\lambda_B = 1000\,\text{Å}\Big/\left(0.64976^3 / k_0'^{2/3}\right) = 3647.053(3647.0533)\text{Å},$$

where $k_0'^{2/3} = \{[1+\left(\sqrt{3}-1\right)^6]/(2\sqrt{3}/3)\}^{2/3} = 0.99930939^{2/3}$ = 0.99953954.

Topological Rydberg constant for hydrogen atoms is calculated by following:

$$R_\infty^H = 4\times 10^7\,\text{m}^{-1}\times 0.6497595264^3/k^{2,552055976} = 1.0973731568513\times 10^7\,\text{m}^{-1},$$

where an exponent in case of using k is following:

$$10\eta_{c1}/k_0^{\eta_1^{10/3}} = 10\eta_{c1}/k_0^{0.64257^{10/3}} = 2.5490381/0.994845224^{0.22894743} = 2.5520559763;$$

$$\eta_1 = 0,99971^3\left(0,63347284/0.646587364\right)0.64976\cdot 0.9999671818^{1/3} = 0.64257042265.$$

k_0 is divergence of curvature of topological space with the Euclidean space at level of gap dimension between three contacted balls,

$$k_0 = \left(\sqrt{3}-1\right)^6 / \left(\frac{2\sqrt{3}}{3} - 1\right) = 0.1539/0.1547 = 0.994845223857.$$

For uncorrected η_1 R_∞^H = 1.0973731570.

According to data of the CODATA 2006 R_∞^H = 1.09737315685·$10^7$$\text{m}^{-1}$ [4].

For ultra-violet absorption spectrum (Lyman series):

$$\lambda_l = 1000\,\text{Å}/(0.1\times 0,64976)^{10/3} k_0 = 911.456(911.27)\text{Å},$$

or $$\lambda_l = 1/R_\infty^H = 1/(1.0973731568...1.0973731568527)\times 10^7\,\text{m}^{-1} = 911.267\,\text{Å}.$$

For infra-red absorption spectrum (Pfund series):

$$\lambda = 1000\times 0.99971\,\text{Å}/\left[/10\left(\sqrt{3}-1\right)^2\right]0,64976^{10/3} k_0^2 = 22782.6(22782)\text{Å}.$$

or $$\lambda = 1000\,\text{Å}/\left[/10\left(\sqrt{3}-1\right)^2\right]0,64976^{10/3} k^3 = 22783(22782)\text{Å}, \quad \text{where } k = 0.9997102488 \leftarrow 0.63999651.$$

These data confirm the corpuscle-wave duality of discrete systems. In the parentheses of equations of Pfund series the data, obtained on the base of spectroscopic measurements and quantum-mechanical calculations are presented.

Values of content of matter energy ε_1, intergalactic gas, stars and neutrino ε_g, dark matter energy ε_2 and vacuum dark energy ε_3 can be obtained directly with PTT equation (1) at $\sigma_{max}(\eta_1) =$ 0,9999671818564 and

$\sigma_{max}(\eta_1)=1$ in line of base sequence of phase transformation in matter as well as content of material substance in cold cellular structure of the Universe:

1→0.930465076654→0.86050635728386→0.7895528450→0.7166952664→**0.64032674326744**→0.5571091981→0.457738137416→0.2856168242…→0.22092884.

0→**0.0695349**→0.13949364→**0.210447155**→0.2833047→0.359673257→0.4428908→0.542262→**0.714383175784…**→0.77907116 (11)

0.9999671818←0.93043216287←0.86047312695←0.7895189656627←0.7166601858958←**0.640289423105**→ 0.5570672723→0.457683678247→0.285467268311→ →0.220928·

0→**0.069567837·(0.069535019)**→0.13952687→**0.2104810343473**→0.283339814→0.359673257→0.4429327277→0.54231632175→0**.714532731689**

→0.779072 (12)

Content of matter energy ε_1, intergalactic gas, stars and neutrino ε_g in the Universe are equal, respectively

$$\varepsilon_1=\left(\sigma_{max}-\sigma\right)\eta_i/(1...\sigma_{max})100\ \%, \qquad (13)$$

where σ_{max}, σ are packing densities of discreteness elements of substances in «overheated» and «overcool» states, i.e. $\sigma_{max}\geq 1$ and $\sigma\leq 1$ when increasing of parameter η_1 (the values are putted in bold) in the equation (1)

$\varepsilon_1=100\cdot(1.022405-0.9529177)\cdot\mathbf{0.7404805}/(1\ldots1.022405) = 5.145\ldots5.033\ \%$,

$\varepsilon_1=100\cdot(0.9999672-0.930432)\cdot\mathbf{0.640289431}/(1\ldots0.9999672) = \mathbf{4.45}\ \%$.

$\varepsilon_1=100\cdot(1-0.930465)\cdot 0.640326745/1= \mathbf{4.45}\ \%$.

$\varepsilon_1=100\cdot(0.999710249-0.93017443)\cdot\mathbf{0.63999651}/(1\ldots0.999710249) = \mathbf{4.45}\ \%$,

$$\varepsilon_g=\varepsilon-\varepsilon_1=\left(\sigma_{max}-\sigma\right)\left(1-\eta_i\right)/\left(1...\sigma_{max}\right). \qquad (14)$$

$$\varepsilon_g=100\cdot(1.02240-0.9529177)\cdot(1-\mathbf{0.7404805})/(1\ldots1.0224) = 1.80\ldots1.76\ \%,$$

$$\varepsilon_g=100\cdot(0.99971-0.930174)\cdot(\mathbf{1}-\mathbf{0.63999651})/(1\ldots0.99971) = \mathbf{2.5}\ \%.$$

$$\varepsilon_g=100\cdot(0.9999672-0.930432)\cdot(\mathbf{1}-\mathbf{0.6402894})/(1\ldots0.999967) = \mathbf{2.5}\ \%,$$

$$\varepsilon_g=100\cdot(1-0.930465)\cdot(1-\mathbf{0.640326743})/1= \mathbf{2.5}\ \%.$$

Content of dark matter energy in the Universe at present time is determined by value of first critical packing density of discreteness elements:

$$\varepsilon_2=\eta_{c1}=\ 100\eta_1^n\%. \qquad (15)$$

0.6340528…0.74048 we obtain following:

$$\varepsilon_2=100\left(0.634053^{10/3}...0.640289^{10/3}...0.64976^{3,45}...0.7405^5\right)\%\ = =(21.90\ldots22.625\ldots22.59\ldots22.26)\%.$$

In this case the contents of substance energy ε_1 and intergalactic gas ε_g as well as dark matter and vacuum energy in the Universe are followings, respectively:

$$\varepsilon_1+\varepsilon_g=(1-0.930465)=(4.45+2.5)=0.0695;\ \varepsilon_2=21.05 \text{ and } \varepsilon_3=71.45\ \%,$$

$$\varepsilon_3=100\%-\left(6,95+21.05...22.26\right)\%=72.0...70.78\%,$$

where $\eta_1=\ 0.2105^{0.2}\ldots0.22262^{0.2} = 0.7322\ldots0.7405.$

Content of exchange radiation energy together with dark matter and dark vacuum energy in the Universe at present time is following:

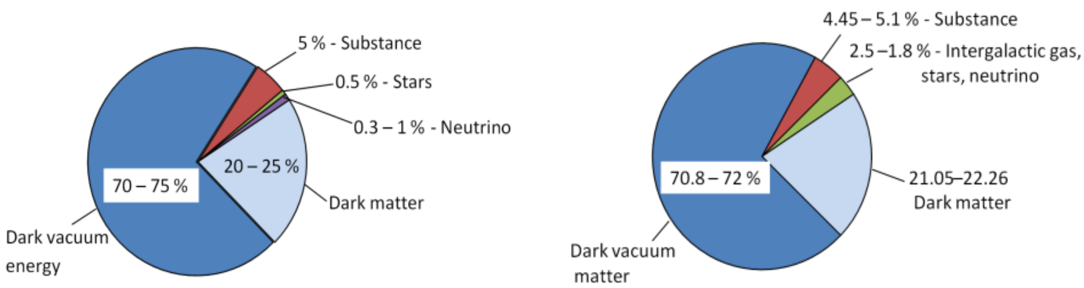
$$\Delta\varepsilon_2=\ \left(0.7404805-0.21045^{0.2}...0.22262^{0.2}\right)100\%\ =\ 0.828236...0\%.$$

or $\Delta\varepsilon_2=100\ \%/\left[2000\left(\sqrt{3}-1\right)^9...0.22262^{0.2}\right] = 0.828131\ldots0\ \%.$

$$\Delta\varepsilon_3 = (0.7404805 - 0.7143832)100\% = 2.6097\%.$$

$$\Delta\varepsilon_3 = (0.7404805 - 0.7145327)100\% = 2.5948\%.$$

Content of exchange radiation energy, vacuum energy and dark matter determines the content of hydrogen and helium in the Universe at present time.



a – by data of V.A Rubakov [6]. **b** –calculated data

Fig.1. Energy balance in the Universe at present time

H= 0.026097/(0.00828 + 0.026097)100 % = 75.91 %, He = 100 % –75.91 % = 24.09 %.

Hubble's constant is one of the ambiguous parameter since its invention. Estimative value of Hubble's constant for the Universe at present time is following:

$$H_0 = \eta_{c1} / 2\,\eta_{c2}\,\left(\sqrt{3}-1\right)^{13} \approx$$

$$\approx (0.2549\ldots0.2542)\ \text{km/(s Mpc)} / 2\cdot 0{,}1\left(\sqrt{3}-1\right)^{13} \approx 73{,}5\ldots73{,}3\ \text{km/(s}\cdot\text{Mpc)}.$$

Adjusted value of the Hubble's constant for content of dark vacuum energy in the Universe as well as for parameters in series (11, 12), where η=1 and η=0.9999671818 are following, respectively:

$$H_0 = (\eta_{c1} / 2\,\eta_{c2}^2\ \eta_1^5)(\eta_{1\max} / \eta_1)^m \le (\eta_{c1} / 2\cdot 0{,}01\,\eta_1^5)(\eta_{1\max} / \eta_1)^m \le$$

$$\le (\eta_{c1} / 2\,z\,\eta_1^5)(\eta_{1\max} / \eta_1)^m \le$$

$$\le (0.2542\ \text{km/(s Mpc)} / 2\cdot 0.01\cdot 0.714383^5)\cdot(0.7404805/0.714383)^2 \le$$

$$\le 68.5\cdot(0.7404805/0.714383)^2 \le 73.3943649822\ \text{km/(s Mpc)},$$

where η_{c1}, η_{c2} are canonic values of first and second critical packing density of discreteness elements $\eta_{c1=}$ $0.63347284^3 = 0.25420494767$ – for radiation and $\eta_{c1}=0.634052826^3 = 0.2549038106$ – for substance; $\eta_{c2}= 0.1$; its packing density η_2 are putted in bold type in the line (11) or (12); m is index of discreteness elements relationship: for Coulombic interaction the parameter m=2; for strong interaction parameter m= $\ge$ 16/3; $\eta_{1\max}$ is density of ordered packing of spherical discreteness elements, $\eta_{1\max}= \pi / 3\sqrt{2} = 0.7404805$; z is relative value of frequency reducing of magnetic waves (red shift) at a distance of light distribution from source (ν_0) to receiver (ν) as a result of energy dissipation, $z = (\nu_0 - \nu)/\nu = \nu_n/\nu$.

In case of large and small distance the parameter $z \approx 0.01$ is according to S.B. Alemanov [4].

Age of vacuum energy of the Universe is following:

$t_0 = 1 / H_0 \ge 1 / 73.3943649822$ km/(s Mpc) $\ge 13.6250242\cdot 10^9$ years $\ge$ 13.6250242 billion years.

Value of the Hubble's constant for dark matter content in the Universe in case of strong interaction of discreteness elements (n = 16/3) is calculated by the following equation:

$$H_0 = (\eta_{c1} / 2\,\eta_{c2}^2\ \eta'_{c1})(\eta_{1\max} / \eta_1)^m = (\eta_{c1} / 2\,z\,\eta'_{c1})(\eta_{1\max} / \eta_1)^m =$$

$$= (\eta_{c1} / 2\cdot 0.01\cdot \eta'_{c1})(\eta_{1\max} / \eta_1)^m.$$

η_{c1} is critical packing density of discreteness elements when topological matter transformations, determined in line (11) or (12).

$H_0 = (0.2549\ km/(s\ Mpc)\ /2 \cdot 0.01 \cdot 0.210447)(0.7404805/0.714383)^{\mathbf{16/3}} =$
$= 60.562427321\ (0.7404805/0.714383)^{\mathbf{16/3}} = 73.3346827717723\ km/(s\ Mpc)$.
Age of dark matter in the Universe is following:
$t_0 = 1/H_0 = 1\ /\ 73.3346827717723 = 13.63611271234565$ billions years.
Relatively of dark vacuum energy as well as values of parameters in line (12), where $(k)\eta_{1max} = 0.9999671818564$ we obtain:

$$H_0 = (0.2542/k^2\ km/(s\ Mpc)\ /\ 2 \cdot 0.01 \cdot 0.7145327316891^5)(0.7404805/0.71453273)^2 / k^2 =$$
$$=68.2406827938951(0.7404805/0.71453273)^{\mathbf{2}}/k^2 = (73.28689937461/0.9999672^2) =$$
$$= 73.29170989139245\ km/(s\ Mpc).$$

Age of vacuum energy of the Universe in this case is following:
$t_0 = 1/H_0 = 1/73.29170989139245\ km/(s\ Mpc) = 13.6441079281934$ billion years.
Relatively of dark matter content in the Universe we obtain:

$$H_0 = (0.2549/k^{16/3}\ km/(s\ Mpc)\ /\ 2 \cdot 0{,}01 \cdot 0.210481037)(0.7404805/0.71453273)^{\mathbf{16/3}} = 60.563278\ 1.20954294 = 73.2538855\ km/(s\ Mpc).$$

Age of dark matter of the Universe at present time is following:

$$t_0 = 1/H_0 = 1\ /\ 73.2538853\ km/(s\ Mpc) = 13.651153\ \text{billion years.}$$

Average values of vacuum energy and dark matter as well as its age are followings, respectively:

$$H_0 = (73.3943649822 \cdot 73.29170989139245)^{0.5} = 73.343019476555\ km/(s{\cdot}Mpc).$$
$$t_0 = 1/H_0 = 1\ /\ 73.343019476555\ km/(s{\cdot}Mpc)= 13.6345627319\ \text{billion years.}$$
$$H_0 = (73.3346827723 \cdot 73.2538855)^{0.5} = 73.2942729\ km/(s{\cdot}Mpc).$$
$$t_0 = 1/H_0 = 1\ /\ 73.2942729\ km/(s{\cdot}Mpc) = 13.643631\ \text{billion years.}$$

The most probable values of the Hubble's constant, calculated due to topological parameters of vacuum energy and dark matter energy as well as their age are followings, respectively:

$$H_0 = 73.343019476555\ km/(s{\cdot}Mpc).,\quad t_0 = 13.634562732\ \text{billion years.}$$
$$H_0 = 73.2942729\ km/(s{\cdot}Mpc).,\quad t_0 = 13.643631\ \text{billion years.}$$

On the base of calculated data the age of dark matter is 8…10 million older then vacuum energy when Universe expansion. At present time it is held the most probable value of the Hubble's constant is $H_0 = 73.2 \pm 0.2$.
Degree of star brightness when determination of the star parameter is determined by random packing density of similar balls:

$$D_{n-1}/d_n = \left[10\eta_1\left(\sqrt{3}-1\right)^3\right] = (3.923 \cdot 0.640326745...0.6402894231)^{n-1} = 2.512^{n-1}.$$

Packing density of discreteness elements of dark matter as a result of vacuum expansion,

$$\eta_{c1} = \left(\pi / 3\sqrt{2}\right)^{16/3} = 0.7404805^{16/3} = 0.20140611$$

is in phase with maximum wave-length λ= 0.201406 calculated with the Planck equation for blackbody radiation. Remained time for the Universe expansion before its compression relatively of vacuum space in the Universe is following:

$\Delta t = 1\ /\ (0.2542\ km/(s\ Mpc)\ /2 \cdot 0.01 \cdot 0{,}2014^{5\cdot 3/16}) \cdot (0.7404805/0.2014^{3/16})^2 -$
$- 13{,}634562732$ billion years $= 17.51515952968 – 13.634562732 \approx 3.87$ billion years.

Full cycle of expansion and compression of switchback homogenous Universe is following:

$$t_{full} = 17.51515953 \cdot 2 \approx 35.03\ \text{billion years.}$$

– remained time relatively of dark matter is following:

$$\Delta t = 1\ /\ (0.2549k^5\ km/(s\ Mpc)\ /2 \cdot 0.01 \cdot 0.2014^{5\cdot 3/16})\ (0.7404805/0.2014^{3/16})^{\mathbf{16/3}}$$

$- 13.63611271375$ billion years $= 17.47000 - 13.636 \approx 3.834$ billion years.

In this case the full cycle of expansion and compression of switchback homogenous Universe is following:

$$t_{full}= 17.47\cdot 2 \approx 34.94 \text{ billion years.}$$

For full returns of switchback Universe from point of singularity, where 0≤ n ≤1 and m≥ 16/3→∞ some solutions (for periods of its development can be followings:

$$T = 1/(0.2549/k^n \cdot \text{km}/(\text{s} \cdot \text{Mpc}) \ /2\cdot 0.01\cdot 0.2014^n)(0.7404805/0.2014^n)^m$$

At m = 16/3, m = 23/3 and $m \to \infty$:

$$T = 1/(0.2549\cdot \text{km}/(\text{s} \cdot \text{Mpc}) \ /2\cdot 0.01\cdot 0.2014^0)(0.7404805/0.2014^0)^{16/3} = 15.8 \text{ billion years}$$

$$T = 1/(0.2549\cdot \text{km}/(\text{s}\cdot \text{Mpc}) \ /2\cdot 0.01\cdot 0.7404805)(0.7404805/0.2014^{3/16})^{16/3} = 58.1 \text{ billion years}$$

$$T = 1/(0.2549\cdot \text{km}/(\text{s} \cdot \text{Mpc}) \ /2\cdot 0.01\cdot 0.7404805)(0.7404805/0.2014^0)^{23/3} = 581.5 \text{ billion years}$$

$$T = 1/(0,2549\cdot \text{km}/(\text{s}\cdot \text{Mpc}) \ /2\cdot 0.01\cdot 0.2014^0)(0.7404805/0.2014^0)^{23/3} = 785.325 \text{ billion years}$$

$$T = 1/(0.2549\cdot \text{km}/(\text{s} \cdot \text{Mpc}) \ /2\cdot 0.01\cdot 0.2014^0)(0.7404805/0.2014^0)^{m\to\infty} \to \infty.$$

Thus, the methods of discrete topology allow calculation the content of substance energy, dark matter, dark vacuum energy in the Universe and their relationship, which was not be established until present time. These parameters are in agreement with literature data [7]. It is assumed the content of substance energy in the Universe most accurately represents of its structure as a spread of the parameters in values in more narrow range.Content of substance energy in case of ordered structure in the Universe is ε_1≈5.15 %; in case of disordered structure in the Universe is ε_1≈4.45 %. Energy content of intergalactic gas, stars and neutrino with ordered structure is ε_g≈ 1.8 % that is not in compliance with its physical state; in case of disordered structure is ε_g≈2.5 % and is in compliance with its physical state.Packing density of discreteness elements of dark matter is in range of 0. 2105…0.2226 and is in accordance with substance critical state. Under low temperature and deep vacuum it can be assumed the critical state of dark matter is permanent resource of electromagnetic radiation like nearly the substance electromagnetic critical point the sound noise is detected. Interaction of discreteness elements of dark matter (index m) is bigger than their Coulomb interaction in dark vacuum energy. In these conditions the dark matter demonstrates a unique property – gravitational repulsion concurrently with local gravitational attraction of cosmic bodies providing their orbital and galactic relative stability.Interaction of radiation with dark vacuum matter and dark matter leads to development of the density fluctuations and reduction of average packing density of discreteness elements with the substance formation. Gravitation of negative pressure of vacuum and dark matter leads to gravitational the Universe expansion with mounting velocity. Observed growing velocity of distant stars and galaxies is connected with their circular movement around that predetermines subsequent the Universe compression.

At presents time the age of the Universe is 13.6441–13.6361 billion years, and in the end of its extension it will be 17.5 billion years. The full cycle of expansion and contraction of the switchback Universe will be 35 billion years. It is reasonable to suppose the primary formation is a matter unlimited in time and in space; the secondary one is the Universe vacuum.

This work was financially supported by the Russian Federation Ministry of Education and Science in the framework of the state task № 11.1550.2014/K, using equipment of High Technology Center at BSTU named after V.G. Shoukhov.

REFERENCES

1. M.E. Aerov, O.M. Todes, D.A. Narinsky, Aparatus with stationary granular layer, Chemistry, Leningrad, 1979.
2. A.L. Afros, Physics and geometry of disorder, Nauka, Moscow, 1982.

3. S.L. Chizhik, Size effects when phase transformation to liquid phase – crystal, Journal of experimental and theoretical physics, 5, Vol. 88 (1985), 1706–1717.
4. S.G. Karshenboim, New recommended values of fundamental physical constants (CODATA 2006), 10, Vol. 178 (2008), 1057–1062.
5. A.N. Kharkhardin, Structural topology of disperse systems, BSTU named V.G. Shoukhov, Belgorod, 2001.
6. Trunov P.V., Alfimova N.I., Vishnevskaya Y. Y., Evtushenko E.I. Effect of type of grinding on energy consumption of production and qualitative characteristics of composite binders [Text] / P.V. Trunov, // Bulletin of BSTU named after V.G. Shoukhov. 2012. №4. P. 37–40.
7. Kharkhardin A.N., Syleymanova L.A., Kara K.A., Malukova M.V., Kozhukhova N.I. The determination of topological properties in polydispersed mixtures on the results of sieve laser and particle size analysis // World Applied Sciences Journal. 2013. № 25 (2). P. 347–353.
8. K.E. Levitin, Geometrical rhapsody, Znanie, Moscow, 1984.
9. J. Ziman, Disorder models. Theoretical physics of homogeneously disordered systems, Mir, Moscow, 1982.